CRC 1227
Designed Quantum States of Matter

GUEST LECTURE

Dr. Vera Schäfer

Max Planck Institute for Nuclear Physics
Heidelberg, Germany

DQ-mat Colloquium

Physikalisch Technische Bundesanstalt
Bundesallee 100, 38116 Braunschweig

Thursday, 23 January 2025, 4.00 pm

"Searching for new physics with new lasing mechanisms and highly charged ions"

Precision measurements of atomic transition frequencies are a promising path for testing theories for new physics beyond the standard model. To achieve even higher precision more sensitive systems and more stable and narrow-linewidth laser sources are required.

Superradiant lasers are a candidate for realising a narrow-linewidth, high-bandwidth active frequency reference, by shifting the phase memory from an optical cavity to an ultra-narrow optical atomic transition. Pulsed superradiance on the mHz transition in 87Sr has achieved a fractional Allan deviation of 6.7*10−16 at 1s of averaging. Moving towards continuous-wave superradiance promises to further improve the short-term frequency stability by orders of magnitude, but requires continuous loading of cold atoms into the strong coupling regime of a cavity.

We demonstrate continuous loading and transport of cold 88Sr atoms inside a ring cavity, as well as the emergence of collective continuous lasing of the atoms on the 7.5kHz transition, 7x narrower than the cavity linewidth, and pumped by the cooling lasers via inversion of the motional states. The lasing is supported by self-regulation of the number of atoms inside the cavity that pins the dressed cavity frequency to a fixed value over >3MHz of raw applied cavity frequency. In the process up to 80% of the original atoms are expelled from the cavity.

In addition, I will present a new project in Heidelberg aiming to use simultaneous precision spectroscopy of two highly charged ions (HCIs) to search for a variation of the fine-structure constant α. HCIs have transitions with strongly enhanced sensitivity to α and reduced sensitivity to common sources of systematic errors. By comparing Cf15+ and Cf17+ we will target a sensitivity for a fractional variation of α of 10-20/year.

All DQ-mat members and all interested are cordially invited to attend.